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SURVEY OF RESULTS OF 30 YEARS OF RESEARCH
ON PHYTOBACTERIOSES IN THE USSR, 1917 - 1947

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One of the first laboratories devoted to phyto-bacterioses was founded by V. I. Vzorov and V. P. Izrail'skiy about 30 years ago.

Of the 400 research studies on bacteriosis, 340 were carried out after 1930. The increased interest in this particular subject is due to the agricultural requirements and phytohygiene stressed in the Stalin Five-Year Plan for reconstruction and agricultural improvement.

GENERAL PROBLEMS OF THE STUDY OF BACTERIOSIS

Diagnosis

This problem was studied in detail, with a view to simplifying existing methods of diagnosis.

Izrail'skiy diagnosed bacterioses in citrus fruits, beans, and tomatoes by the serological method now in use in quarantine laboratories.

By various agglutination methods, Belen'kiy in 1940 and Galach'yan in 1946 diagnosed, respectively, black bacteriosis and basal bacteriosis in wheat. In 1939, Tipograf had used similar methods to determine the infection of potatoes by ring rot.

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In 1938, Artem'yeva (1938) used Gram's staining method to diagnose bacterial cancer in tomatoes, while Tipograf studied ring rot in potatoes.

Lebezinskaya in 1935 and Vzorov in 1936 identified phytopathic bacteria and isolated them from saprophytic forms by adding a small amount of gentian violet to the culture medium.

In 1938, Verderevskiy and Votolkina diagnosed an infection of cottonseed based on the appearance of pathogenic processes in the cotyledons. During analysis by their method, they often discovered rotting in the young shoots, caused by the development, in the plant, of the saprophytes identified by Lebedeva as cohaerens Gottheil.

Gorlenko developed a method for analyzing bacteriosis in cucumber seeds in 1947. It can also be used for other plants, such as beans, soybeans, melons, and pumpkins.

In 1937, Fedotova developed a serological method of determining the resistance of various cotton plants to diseases, especially gummosis.

Bacteriophages of Phytopathogenic Bacteria

In 1928, Izrail'skiy proved that the absence of bacteria in tumors caused by *B. tumefaciens* Sm. et Tows, was due to an accumulation of bacteriophages. Even earlier in 1926, Yachevskiy had published an article on the use of bacteriophages in phytopathology. Bacteriophages of *B. malvacearum* Sm. were discovered by Lebedeva in 1936, of *B. tabacum* Wolf et Foster by Obermeyer in 1935, of *B. mori* (Lamb et Boyer) Smith by Biberdiyeva in 1936, and of many phytopathogenic bacteria by Chistoserdova in 1938. The use of bacteriophages to control cotton gummosis and tobacco mosaic was studied by Lebedeva in 1936 and by Novikova in 1940.

Bel'tyukova demonstrated in 1946 that auxin and other phytohormones decreased the virulence of the causative agent of cotton gummosis and tobacco mosaic and increased the resistance of plants to these infections. She also worked on the antibiosis between the phytopathogenic and soil microbes in 1940. Khetagurova and Olintskaya also worked along these lines in 1941. Research by Voronkevich in 1947, Izrail'skiy, and others proved that *B. aroides* Tows, *B. carotovorum* (Johnes) Burgw. and *B. mori* (Lamb et Boyer) Smith die rapidly in nonsterile soil.

An interesting study of the parasitic evolution of phytopathogenic bacteria, as shown in the infection of iris by *B. fluorescens* (Fluegge) Lemiet Nehm., was made by Kublanovskaya in 1937, while the development of *B. mesentericus vulgatus* Fluegge in apricots and of other bacteria was studied by Avakyan in 1945. In 1947, Khetagurova also did valuable work on the biological peculiarities of phytopathogenic bacteria.

Geographical Extent

The first list of bacterioses published in the Soviet Union by Vzorov in 1938 described 56 types, 16 of which were originally recorded in Europe. In 1947, Gorlenko brought the list up to date and classified the diseases according to the frequency of occurrence and geographical limits in the USSR. At present, 67 varieties of cultivated plants are listed as affected by bacterioses and the number of such diseases is given as 80. Flora Infected by Phytopathogenic Bacteria in the Soviet Union will be published next.

Two important books, A. A. Yachevskiy's Bacterioses of Plants and G. K. Burgvit's Phytopathogenic Bacteria were published in 1935.

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RESULTS OF RESEARCH ON VARIOUS BACTERIOSES

Bacteriosis of Cereals

The earliest studies on this subject were made by Yachevskiy in 1925 and by Fomin in 1928. Recently, it has been established that the annual spreading of the so-called black bacteriosis is caused by seeds and the debris from harvests. Disinfection of seeds, especially with copper sulf., has proved effective. Definite laws were discovered governing the susceptibility of different types of soft wheat; for example, red-spiked wheat is more susceptible to infection than white-spiked wheat. In 1939, both Trunov and Gorlenko introduced methods of controlling black bacteriosis. In 1946, Galach'yan suggested a method of determining the pathogenicity of various forms of diseases caused by *B. atrofaciens* McCull. Gorlenko and Naydenko in 1945 discovered *B. coronafaciens* Ell. in the Soviet Union and established the fact that the residue of diseased plants was the source of this infection in oats.

Gummosis in Cotton

The first publication on this disease was Cotton Diseases in 1930, embodying the studies of Yachevskiy and his co-workers. Verderevskiy in 1938, Babayan in 1939, Moskovets, Vasil'yev, and others worked on the etiology of gummosis and its development in the ground. In 1940, Grushevskiy and Vasil'yev improved methods of disinfecting cottonseed and designed a special setup for this work in gins. Verderevskiy's experiments in 1938 with suspensions of *B. malvacearum* Sm. made it possible to introduce a resistant type of cotton into new areas.

Tobacco Bacterioses

Tverskoy established the presence of a bacterial mosaic in the Soviet Union. Similar research was conducted by Kokhanovskaya in 1929, Popova in 1940, Gorlenko and Kuprianov in 1930, and Medish in 1931. In 1935, Bel'tyukova, Samotavetova, Lebedva, and Obermeyer found that the causative agent of gummosis, *B. tabacum* Wolf et Foster, died in the ground but was preserved in seeds and debris. These bacteria infected other plants also. Methods of treating the roots and seeds for this and other diseases were worked out by Grusheva.

The causative agents of other spotty leaf diseases -- *B. angulatum* Fr. et Murr., *B. pseudozooglea* Honing, *B. hecteroceum* Wsorrow -- were described by Vzorov. The latter bacterium has unstable parasitic characteristics. The bacterial affection of the tobacco stain by *B. carotovorum* (Jones) Burgw. causing rotting in the pith was studied by B. Bel'tyukova and Popova in 1936.

Bacteriosis of Sugar Beets

Murav'yev in 1939, Morochkovskiy in 1935, Kochur in 1936, and Babitskaya in 1934, among others, established the fact that bacteriosis in beets, with few exceptions, developed in weakened plants, causing tail rot, necrosis of the fascicles and other pathological conditions. *B. scabiegenum* Faber (bacterial scab) was first observed in the Soviet Union by Kalashnikov in 1928. The work of Buromskiy and Matyushenko in 1934 on mucoid diseases also deserves mention.

Bacterioses of Vegetables

1. Tomatoes

Research on bacterial cancer indicated that the infection was superficial, and that the causative agent was transmitted by seeds and could not live in the ground. Izrail'skiy and Osnitskaya studied its propagation during the vegetative period. In 1938, Izrail'skiy and Artem'yeva developed methods of disinfecting

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tomato seed with Zbarskiy's bactericide and corrosive sublimate. Through the use of *Solanum pimpinellifolium*, Yatsynina succeeded in 1941 in introducing varieties of tomatoes resistant to this disease. It has been established that tomato cancer exists in many parts of the Soviet. Hitherto it has probably been confused with other diseases. Effective measures to control it have been developed.

In 1927, Burgvits ascribed top rot to bacteriosis. Later, in 1946, Balach'yan proved that it was caused by bacteria transmitted from seeds, but Osnitskaya (1937) and Alimbekova (1940) proved that the real cause was irregular watering which killed the cells in the top of the fruit, and that the bacteria were only secondary. In 1937, the occurrence of black bacterial spot caused by *B. vesicatorium* Doidg. was noted by Yatsynina in the Soviet Union. Later, Serebryakov discovered it in Krasnodar and elsewhere. Black spot does great damage. In 1947, for example, in the Don River valley below Voronezh, this disease was so severe that whole districts were ruined. In 1927, Burgvits attributed water rot to an organism resembling *B. aroideae* Tows.

2. Cucumbers

The first studies of bacteriosis in cucumbers were made by Potebnya in 1915 and Burgvits in 1927. Gorlenko and Voronkevich established the developmental cycle of the causative agent of this disease and proved that the infection was transmitted by seeds. The infection was internal. They introduced a method of treating seeds with 1.3 percent solution of "NIUIF-1." In 1935, Kalashnikov pointed out that the disease occurred in hothouses only when the moisture condensed into drops and the temperature did not exceed 19 degrees centigrade. Discussions arose as to the interrelation of *B. lachrymans* Sm. et Br. and *Sclerotium melophthorum* Prill et Del. Potebnya (1915) was the first to assert that the fungus developed in bacterial ulcers but was not the causative agent of the disease. This was confirmed by Galach'yan in 1937. However, Pimenova's 1935 experiments confirmed by Shneyder of our laboratory, proved that under very humid conditions this fungus could cause spotting on the cucumber, but only if the cucumber were already injured.

In 1939, Yatsynina described a leaf and fruit bacterial spot in melons caused by a species of *B. lachrymans* Sm. et Bryan, peculiar to melons, in an independent form, forma *melonis* Jaccinina. The affection of gourd blossoms in hothouses, caused by *B. mesentericus vulgatus* Fluegge, was described by Burgvits.

3. Cabbage

In 1940, Gordiyenko developed a treatment for vascular bacteriosis which practically eliminated this disease. He discovered that cabbage in the ground is subject to two bacterioses -- vascular and mucoid. Later, Gorlenko and Voronkevich proved that vascular bacteriosis was caused by *B. aroideae* Tows. and *B. carotovorum* (Jones) Burgw., which die in the ground. They are not transmitted by seeds but are preserved through the winter in the remains of diseased plants lying on the ground. Voronkevich introduced a method of controlling mucoid bacteriosis in 1947. The same year, Starygina and Shishelova came to the conclusion that a number of bacteria were responsible for this disease.

4. Onions

The only infection noted in onions, by Vzorov in 1938, is caused by *B. corci* Mizaz, but if the bulb is damaged by the onion fly, a soft bacterial rot occurs from which *B. carotovorum* Jones can be isolated.

5. Carrots

Sinitsina attributed the great losses occurring in the Tadzhikistan carrot crop to *B. destructans* (Potter) Macata. Yatsynina found a leaf disease, caused by *B. carotae* (Kendr.) Burgw., in Kazakhstan and, later, in Voronezh Oblast.

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6. Beets

Burykhina in 1945 and Yashnova in 1947 reported that in various localities edible beets are affected by "tuberculosis" of the root, caused by *B. beticola* Sm. Br. Tows.

Bacteriosis of Legumes

Detailed studies of bacteriosis in kidney beans were carried on by Galach'yan in 1939 and Artem'yeva in 1938. The most frequent cause of this disease in the common bean is *B. phaseoli* Smith. Somewhat less frequent causes are: *B. phaseoli* v. *fuscans* (Burkh.) Burgw., *B. medicaginis* v. *phaseolicola* (Burkh.) Link. et Hall, and in other varieties, *B. vignae* Gardn. et Kendr. The infection is embedded so deep in the seed that no effective method of disinfection has as yet been found. Galach'yan studied the resistance of various types of beets against bacteriosis in 1939.

In 1936, Zazhurilo first discovered bacteriosis of peas in Voronezh. In 1945, Burykhina found it to be responsible for the great damage in Barnaul.

Bacteriosis of Leguminous Fodder Plants

Various articles (1939 - 1941) have pointed out that lucerne, and sometimes sweet clover, were susceptible to *B. insidiosum* (McCull) Stapp. The Institute of Cotton Farming in Tashkent published a collection of articles, edited by N. G. Zaprometov, on this problem.

B. radiciperda Javor., the cause of a new disease of lucerne and other legumes, described by Zhavoronkova in 1931, so closely resembles *B. insidiosum* (McCull) Stapp that there is little reason to consider it an independent form.

An infection of clover by *trifolium* F. W. W. McCull was discovered by Meyer in Ufa in 1934.

Bacteriosis of Potatoes

Studies were made of ring rot, withering, black stem, and rotting during storage. The causative agent of ring rot in the potatoes of the northern and central belts of the Soviet Union is *B. sepedonicum* Speck, first noted in the USSR by Belen'kiy in 1940. The collective of co-workers in the bacteriosis laboratory of the Moscow Affiliate of the All-Union Institute for Plant Protection and the Institute of Potato Farming established the extent, cause, properties, and developmental cycle of this disease. In 1940, Belova studied the pitted form of ring rot caused by *B. sepedonicum* Speck and concluded that the infection started in autumn, developed in a few months into spots under the skin, and finally attacked the vascular ring, causing withering. Seedlings or injured tubers were very susceptible. This data was confirmed by Kukin of our laboratory.

Until recently, statistics available on black rot were mainly concerned with its pathogenicity and the agronomic measures for its control. Korotkova's work at Leningrad Plant Breeding Station proved that the disease is transmitted from the soil and spread by tubers used in planting. She also introduced a method of determining plant resistance to this disease.

In 1938, Bel'tyukova discovered a new form of bacterium attacking the vascular fascicles of tubers and proved that vernalization increases resistance against disease during storage.

Bacteriosis of Fruit Trees

Information on root cancer caused by *B. tumefaciens* Sm. et Tows. is largely restricted to the data on its propagation. Experiments to ascertain its cause

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were conducted by Izrail'skiy in 1928 and Kapshuk in 1938. Yakovleva in 1933 and Lopatin in 1939 carried out interesting work on the infectiousness of the disease. The latter indicated that periods of drought favored root cancer in cherry trees. Disinfection and other problems have been treated by Boloshinova in 1930, Izrail'skiy in 1928, Kalyayev in 1935, Nesterova in 1939, Smirnova in 1935, and Vinogradova and Pershina in 1937.

Among other works on fruit-tree bacteriosis, studies by the following authors deserve mention: V. I. Serbinov (1940) on pruni Sm.; Izrail'skiy and Stepunina (1940) on *B. cerasi* Griff.; and Mirzabekyan (1946) on *B. armeniacum* Panos. et Mire, (described in 1940 as occurring only in Armenia). Also in Armenia, in 1945, Avakyan studied a form of apricot infection caused by *mesentericus vulgatus* Fluegge -- an independent example of the transition of a saprophyte into a parasitic form.

In Gorlenko's synopsis on bacteriosis of fruit trees in 1946, he stated that there is no *B. amylovorum* Sm. in the Soviet Union, and that cases attributed to it are caused by *B. cerasi* Griff.

Research on bacteriosis of citrus trees initiated recently, proved that it is caused by *B. citripustule* C. Smith. Measures to control this necrosis were introduced by Amerikov in 1941, Goryadze in 1940, and others. There is no cancer of citrus trees caused by *B. citri* Doidg. nor any tubercle on olive trees in the Soviet Union.

Bacteriosis of mulberry trees, *B. mori* (Lamb et Boyer) Smith, discovered by Zaprometov in 1931 in Central Asia, and subsequently studied by Izrail'skiy, Starygina, and others in 1940, has unfortunately become one of the best-known bacterioses in this country.

Miscellaneous Bacterioses

Research has also been conducted on the following cases: coriander by Klaptsova in 1940; rubber plants by Kalinenko in 1939, and others; stock by Struminskaya and Pershina in 1941; flax by Berezova and Savchenko in 1935; iris by Mublanovskaya in 1937; buckwheat by Saltykovskiy in 1939; and peanuts by Vachnadze in 1940.

Conclusion

The results of research on bacteriosis in the Soviet Union can be summarized in the following general terms:

1. As a result of the research carried out by whole collectives, each one taking a different plant, it has been possible to treat a given problem from every aspect.
2. The diagnosis and extent of bacteriosis, some phases of bacteriophagia and antagonism, and general problems have received sufficient attention; but plant immunity and the interrelation of phytopathogenic bacteria and their environment still require study.
3. The valuable research conducted on cotton gummosis, bacterioses of tobacco, cereals, cucumbers, tomatoes, cabbage, potatoes, and legumes makes it possible to introduce more effective means of control in the future.
4. Work on the geography of bacterioses has revealed many new diseases which must now be studied.

Much has been done, but much remains to be done on the problems presented by phytopathogenic bacteria and their interrelation with plant hosts, soil microflora, insects, etc. Such studies would be of great practical and theoretical value.

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